Computing Support for Virtual Communities of Practice

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ABSTRACT

This document describes a research and development project - Semantic Web and Cooperative Problem Solving for Online Communities of Practice. The aim of the project is to build a system supporting Cooperative Problem Solving within the framework of online Communities of Practice, applying the concepts of the Semantic Web. The document presents the background, objectives and partial results of the project.

Keywords: Community of Practice, Online Communities, Semantic Web, Computer Supported Collaboration

1. INTRODUCTION

A Virtual Community is an aggregation of individuals or businesses interacting around a shared interest, where interactions are supported by technology and guided by some norms [7]. A Community of Practice (CoP) is a group of people sharing a concern for something they do and learning how to do it better by interacting regularly [9]. A Virtual Community of Practice is a CoP where interactions are supported by technology.

VCPs rely on computer support to enable interactions and collaboration between members. The amount of support differs depending on the nature, scope and field of interest of the Community, from member registration, to collaborative review, to email forums. However, these only provide basis technical support for community work. The aim of this research is to investigate generic support for core “creative” aspects of community work. Secondly, we aim to build a system which is able to deliver such support through online community portals.

The first difficulty is defining the notion of creativity and the core work required to achieve it. Different communities assign different meanings to this notion. For some, creativity is about discovering algorithms to solve particular computing problems in the most efficient ways considering both the time and memory used. For others, creativity is about correcting bugs documented in some widely-used software packages or finding ways around them. Yet for others, creativity is about discovering new ways to teach mathematics to children.

Generically, the core creative work of the Community is when its members respond to the problems posted by their peers, and are working together to find solutions to them. Problems, solutions and what it means for a given solution to solve a given problem have to be concretely defined in domain-specific terms: algorithms, code, patches, numbers, games, etc. However, we postulate that human-driven processes for cooperative problem-solving as well as computer systems supporting such processes may largely ignore such domain-specific details and operate instead in abstract domain-independent terms: problems, solutions, resources, statements, properties, etc.

Inline with this postulate, the first objective of this research is defining a domain model for Cooperative Problem Solving in Virtual Communities of Practice. The model will be described in a formal notation, suitable for writing software specifications and with proof support. The second objective is to define, on the basis of the model, a systematic solution-building process to address a given problem description. Finally, we aim to build a concrete system to provide adequate computing and communication support for this process. The system will be build from its specification, created on the basis of the domain model and applied in the context of the problem-solving process. The implementation of the system will rely, we envision, on the technology stack of the Semantic Web [1]. Particularly, the subject-property-object triples of the Resource Description Language [10] will provide the semantic foundation for describing and relating resources, among them problems, solutions and their relationships.

The rest of the paper is as follows. Section 2 provides background information in three areas related to the paper. Section 3 presents our research objectives. Section 4 describes the results obtained so far. Finally, Section 5 draws some conclusions.

2. BACKGROUND

This section provides a brief account of three areas related to this paper: Communities of Practice, Semantic Web and Collaborative Problem Solving.

2.1. Communities of Practice

The term Community of Practice (CoP) is used to identify a group of people that share interest in some topic, problem or have a common work background [2]. In essence, members of a CoP share a common knowledge domain that brings them together with the aim of interchanging experiences.

CoPs have existed for many years and are usually born in a natural, informal way, without its members even realizing they are indeed members of a CoP. CoPs can be self-organized or sponsored. Self-organized CoPs are informal and fragile, continuously evolving and adapting to changes. In contrast, Sponsored Communities are initiated and managed formally; their members play specific roles within the community and identify themselves with it [12][13].

Community members may work in the same office, in different offices of the same organization or in different organizations. They can even live in different cities or countries. The members can communicate through phone calls, face-to-face meetings or through electronic means like e-mail, instant messaging or others.

CoPs emerge from the desire to enrich the knowledge domain, to increase individuals' knowledge, to make work more effective, to find better solutions to problems, or simply to understand better the topic of interest. All such goals build upon the shared knowledge and individual expertise of community members.

CoPs are proving more effective than traditional knowledge organizations, especially for cooperative problem solving. This is because CoPs [2]: (1) connect people who might not have the possibility to interact otherwise, (2) provide a context for people to share information, (3) enable dialog to explore new possibilities and solve problems, (4) stimulate learning, supporting communication, coaching, self-reflection, (5) introduce collaborative processes within and between organizations to encourage the flow of ideas and information, (6) help people organize and (7) generate new knowledge.

2.2. Semantic Web

Semantic Web is an extension of the World Wide Web in which information is given well-defined meaning, enabling computers and people to work in cooperation [1]. It brings to the Web the idea of having data defined and linked in a way that it can be used for effective discovery, automation, integration and reuse across applications. This not only implies receiving more exact matches when searching the Web but also that the information from different sources can be easier integrated and compared.

In Semantic Web, every entity is considered a resource and resources: are uniquely identified, are described through associated metadata and can be linked to other resources. Semantic Web relies on a set of principles, and these principles are implemented in several layers of technologies and standards:

1) The first layer provides the capability to identify and encode data. It consists of the Universal Resource Identifiers (URIs) and the UNICODE standard.
2) The second layer provides the syntax for describing data. It consists of the Resource Description Framework (RDF). Together with XML and XML Schema, RDF enables the integration of Semantic Web with other XML standards.
3) The third layer makes it possible to describe properties of data. It consists of the RDF-Schema language. Both RDF and RDF-Schema enable the definition of vocabularies that can be referred with URIs and allow making statements about data with URIs. The layer provides syntactic interoperability.
4) The fourth layer enables describing relationships between the data. Consisting of various ontologies, it provides support for the evolution of vocabularies by allowing the definition of relations between concepts.
5) The top three layers are Logic, Proof and Trust. The Logic layer enables writing rules and axioms, which could be used by the Proof layer to establish formal proofs. The Trust layer provides the mechanism to establish trustworthiness of a given proof. All three layers are currently under research.

The explicit representation of the semantics of data with Semantic Web will enable a new level of services. With machine-processable knowledge, automated services will support humans in the tasks that require intensive use and processing of information. Semantic Web technologies, will bring about the degree of automation and scalability necessary in many application areas, particularly in knowledge management systems [14].

2.3. Cooperative Problem Solving

Problem-Solving CoPs are communities that interact and exchange knowledge and ideas about a particular topic of interest with the aim of finding concrete solutions to well described problems in the area.

Members of the community post new problems, provide solutions to already known problems and share individual expertise. In the process, they develop new knowledge and discover new solutions. This approach to problem solving has many advantages, as it: (1) improves creativity, (2) increases confidence in the process, (3) permits finding multiple optional solutions to a single problem, (4) permits discovering better solutions to already solved problems, (5) exposes each member to the skills and abilities of his/her peers and (6) allows the reuse of solutions to previous problems in new defined ones.

These advantages outweigh the inherent difficulties to be expected in problem-solving in general, but certainly do not eliminate them. Cooperative work requires commitment, acceptance of others' opinions, and willingness to work towards achieving a consensus. For this to occur, communication between members must be designed carefully [15].

3. OBJECTIVES

The broad objective of this work is to build support for Cooperative Problem Solving in online Communities of Practice, based on formally-defined models of domains, processes and systems. In concrete terms, the following four objectives have been formulated:

1) *models* – to produce a domain model for Cooperative Problem Solving in online Communities of Practice.
2) *process* – to design a human-driven process for building a solution to a given problem description through contributions by members of the community.
3) *system* – to specify, design and implement a system to support the process for collaborative problem-solving, using technologies and standards of Semantic Web.
4) *application* – to demonstrate how the developed system can be used as part of community portals, using the UNeGov.net - Community of Practice for Electronic Governance portal as particular example.

In particular, we aim to provide a formal definition for the concepts of resources, properties and statements, in the style of Resource Definition Framework (RDF). Problems and solutions patterns will become particular kinds of resources, decomposed into simpler sub-problems or partial solutions, and related through relevant properties and statements. The model will also define the concepts inherent to Communities of Practice, such as: member, community, resource, topic, expert and others. It will be described in a natural language and then formalized using the RAISE Specification Language (RSL) [5].

A process of Cooperative Problem-Solving will be specified in RSL, along with its supporting system. The system will be designed using UML and implemented in Java. During development, we plan to review and define new ontologies for the domain. The system will be applied as part of the UNeGov.net community portal. This experience will be analyzed and explained. In the end, we plan to summarize the outcomes of the research and development, experience gained, difficulties encountered and directions for future work.

4. RESULTS

We report here on three initial results of this work: a repository to underpin Collaborative Problem Solving, a process to carry out Collaborative Problem Solving on the basis of this repository and an implementation to support this process, deployed as part of the UNeGov.net portal.

4.1. Repository

We assume that the community relies upon a shared repository of resources, properties and statements, which is both used and developed by the community:

1) *resources* - community assets categorized into classes, comprising papers, projects, software, organizations, people, problems, solutions and others.
2) *properties* – relations between resources or data about resources, defined as binary relations between pairs of resources or between resources and simple values.
3) *statements* – expressions about resources and their properties. Statements are triples of a subject (resource), property and object (resource or data).

Figure 1 depicts the example repository, with various problem-related resources, properties and statements. For instance, it shows how members describe problems, how problems are decomposed into sub-problems, how members propose solutions in terms of existing resources, how partial solutions are part of the overall solution.

4.2. Process

On the basis of the repository, we propose that the process of Collaborative Problem Solving is carried out step-by-step in the following six phases:

1) *problem description* – a member adds a problem description as a new resource to the repository;
2) *problem exploration* – the problem is analyzed by adding statements linking it to existing resources;
3) *problem matching* – similarities between the problem and other problems in the repository are identified;
4) *solution design* – the problem is decomposed into sub-problems which are then added to the repository;
5) *solution refinement* – new statements, resources and properties related to the solution are added, partial solutions are linked with the solution when available;
6) *solution deployment* – adding a solution statement when all sub-problems are solved.

Figure 2 illustrates how the process is carried out, particularly how the number of statements about problem resources increases during all phases. It also shows how the number of unsolved sub-problems increases during solution design and decreases during solution refinement phases. The process can be carried out collaboratively since sub-problems can be assigned to different members, who in turn apply the same process for solving them.

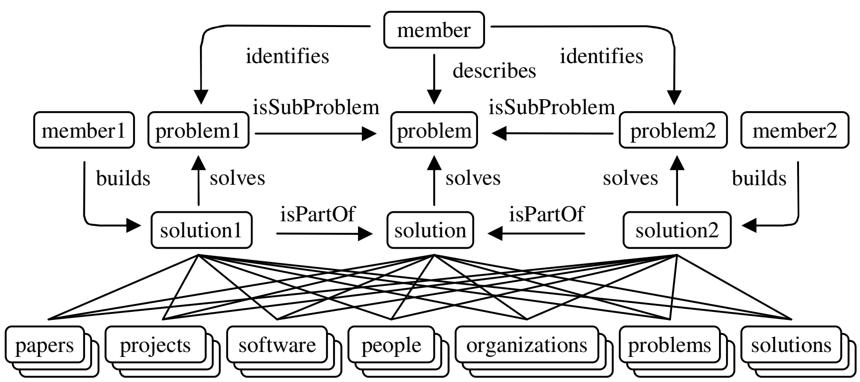

Figure 1: Repository for Collaborative Problem Solving

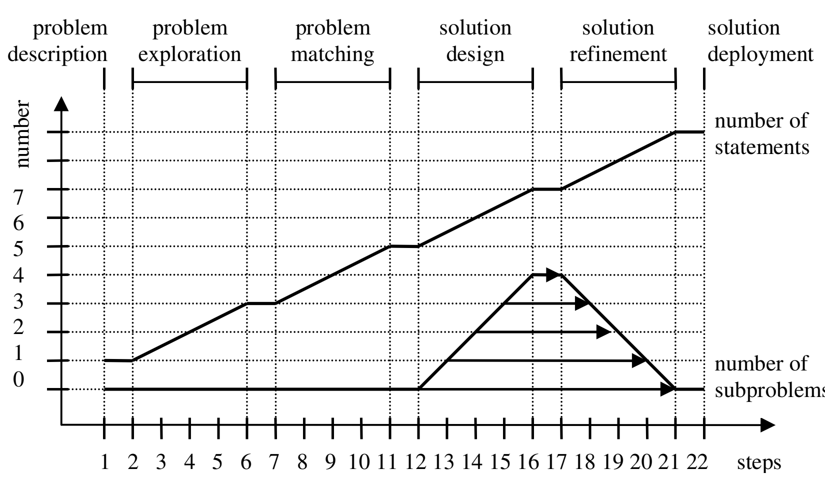

Figure 2: Process for Collaborative Problem Solving

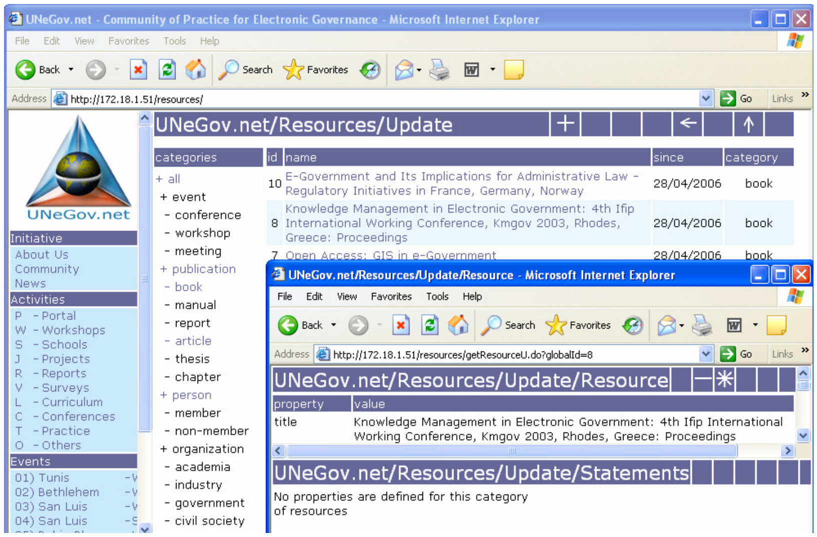

Figure 3: Repository Implementation as part of UNeGov.net

4.3 Implementation

Figure 3 shows how the initial implementation of the repository is deployed as part of the UNeGov.net portal [8]. The bottom window shows the current categories of resources, such as all, event, conference, publication or book. For selected category, the list of all resources in this category is displayed. Each resource in the list can be selected, causing the top window to display the detailed properties of this resource (top part of the window) and the statements relating this resource through various properties with other resources (bottom part).

5. CONCLUSIONS

The main objective of this paper was to present the rationale, objectives and initial results of the research project to support Cooperative Problem-Solving in Virtual Communities of Practice.

First, we described what Virtual Communities of Practice are, how community members interact, the type of work they carry out, and the need and challenges to build computer support for community work. Second, we outlined the concepts related to Communities of Practice, Cooperative Problem Solving and Semantic Web. Third, we presented our research objectives in four areas: modeling the domain, designing the process to drive Collaborative Problem Solving, developing a system to support this process, and deploying this system as part of the UNeGov.net - Community of Practice for Electronic Governance portal. Fourth, we present initial results obtained thus far, such as the model of the repository, process description and the implementation.

Future work involves extending the model with community concepts, defining more types of resources, exploring automation of some of the process phases, and assessing the process in various domains of knowledge.

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